PB91-162446

Succeeding at Waste Minimisation

(U.S.) Environmental Protection Agency, Cincinnati, OH

1990

U.S. Department of Commerce
National Technical Information Service
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(Please read Instructions on the reverse before completi

1. REPORT NO. EPA/600/D-90/229	2.	3. PB91-162446
4. TITLE AND SUBTITLE Succeeding at Waste Minimization		5. REPORT DATE 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Mary A. Curran and Harry M. Freeman		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. EPA, ORD, OEETD, RREL 26 W. Martin Luther King Dr. Cincinnati, Ohio 45268		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Risk Reduction Engineering Laboratory-Cinn., Ohio Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Symposium Paper 14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES
M. A. Curran (513) 569-7837 (Comm.) (FTS) 684-7837
Special Wastes Symposium. Geneva, Switzerland, September 20-22, 1989.

16. ABSTRACT

The EPA's progress over the last eighteen years in improving environmental quality through its media-specific pollution control programs has been substantial. However, EPA realizes that further improvements can be realized by pursuing pollution prevention strategies through a multi-media waste minimization approach. Many public and private organizations in the United States support waste minimization as an approach to reducing waste generation. The EPA encourages waste generators to carry out assessments in their facilities to identify opportunities for waste minimization. This paper describes the six elements of a waste minimization program as recommended by the EPA.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field, Group

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	11
	20. SECURITY CLASS (This page)	22. PRICE
	UNCLASSIFIED	

EPA/600/D-90/229

PB91-162446

SUCCEEDING AT WASTE MINIMISATION

Mary Ann Curran* and Harry M. Freeman
(US Environmental Protection Agency, Cincinnati, Ohio, USA)

1. Introduction

The phrase "waste minimisation" is heard frequently at technical meetings and conferences held for individuals working in the field of hazardous waste management. With disposal options becoming increasingly difficult to find and costly, generators are realising the need for seriously considering ways to reduce wastes.

The US Environmental Protection Agency (EPA) defines waste minimisation as the reduction, to the extent feasible, of any solid or hazardous waste that is generated or subsequently treated, stored, or disposed of. Waste minimisation techniques include source reduction or recycling activities that diminish either the volume or the toxicity of a hazardous waste being generated. Like all innovative solutions to waste management problems, waste minimisation requires careful planning, creative problem solving, changes in attitude, sometimes capital investment, and, most importantly, a real commitment. The pay-offs for this commitment, however, can be great. Waste minimisation can save money through more efficient use of valuable resources and lowered treatment and disposal costs. Waste minimisation can also reduce a generator's financial liabilities and his or her contribution to potential adverse environmental impact. Finally, waste minimisation is good policy and can improve a company's image in the public eye.

2. Federal regulatory requirements in the United States

With the passage of the Hazardous and Solid Waste Amendments (HSWA) in 1984, the United States Congress established a national policy declaring the importance of reducing or eliminating the generation of hazardous waste:

"The Congress hereby declares it to be a national policy of the United States that wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize present and future threat to human health and the environment."

In this declaration, Congress established a clear priority for reducing or eliminating the generation of hazardous wastes (a concept referred to as waste minimisation) in preference to managing wastes that were "nevertheless" generated.

The transfer of hazardous constituents from one environmental medium to another does not constitute waste minimisation. Neither would concentration conducted solely for reducing volume unless, for example, concentration of the waste allowed for recovery of useful constituents prior to treatment and disposal. Likewise, dilution as a means of toxicity reduction would not be considered waste minimisation, unless later recycling steps were involved[1].

In a related action, the EPA published in the Federal Register, on 26th January 1989, a proposed policy statement on source reduction and recycling. This policy commits the Agency to a preventive strategy to reduce or eliminate the generation of environmentally harmful pollutants which may be released to the air, land, surface water, or ground water. It further proposed

* Author to whom any enquiries should be addressed.

to incorporate this preventive strategy into the EPA's overall mission to protect human health and the environment by making source reduction a priority for every aspect of Agency decision-making and planning, with environmentally sound recycling as a second priority over treatment and disposal. The Agency's encouragement of waste minimisation is an example of the pollution prevention policy for RCRA (Resource Conservation and Recovery Act) hazardous wastes.

Congress also enacted several provisions in the HSWA for implementing hazardous waste minimisation. These include a generator certification on hazardous waste manifests and permits for treatment, storage, or disposal of hazardous wastes. These certifications (effective as from 1st September 1985) require generators to certify two conditions: That (1) the generator of the hazardous waste has a programme in place to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable; and (2) the proposed method of treatment, storage, or disposal is that practicable method currently available to the generator which minimises the present and future threat to human health and the environment.[1]

In addition, Congress also added a new provision in 1984 that requires hazardous waste generators to identify in their biennial reports to the EPA (or the State): (1) The efforts undertaken during the year to reduce the volume and toxicity of waste generated; and (2) the changes in volume and toxicity actually achieved in comparison with previous years, to the extent that such information is available prior to 1984.

Inventory management and improved operations

- Inventory and trace all raw materials.
- Purchase fewer toxic and more non-toxic production materials.
- Improve material receiving, storage, and handling practices.

Modification of equipment

- Install equipment that produces minimal or no waste.
- Modify equipment to enhance recovery or recycling options.
- Re-design equipment or production lines to produce less waste.
- Improve operating efficiency of equipment.
- Maintain strict preventive maintenance programme.

Production process changes

- Substitute non-hazardous for hazardous raw materials.
- Segregate wastes by type for recovery.
- Eliminate sources of leaks and spills.
- Separate hazardous from non-hazardous wastes.
- Re-design or reformulate end-products to less hazardous.
- Optimise reactions and raw material use.

Recycling and reuse

- Install closed-loop systems.
- Recycle on-site for reuse.
- Recycle off-site for reuse.
- Exchange wastes.

Table 1.
Waste minimisation approaches and techniques.[6]

3. Waste minimisation approaches and techniques

Waste minimisation is inevitably site-specific and plant-specific, but a number of generic approaches and techniques have been used successfully across the country to reduce many kinds of industrial waste.

Generally, waste minimisation techniques can be grouped into four major categories: inventory management and improved operations, modification of equipment, production process changes, and recycling and reuse. Such techniques can have applications across a range of industries and manufacturing processes, and can apply to hazardous as well as non-hazardous wastes.

Many of these techniques involve source reduction, i.e. the preferred option in the EPA's hierarchy of waste management. Others deal with on-site and off-site recycling. In practice, waste minimisation opportunities are limited only by the ingenuity of the generator. In the end, a company looking carefully at bottom-line returns may conclude that the most feasible strategy would be a combination of source reduction and recycling approaches. The approaches outlined in Table 1 provide waste minimisation examples for generic and specific processes.

4. Elements of a waste minimisation programme

So, what is a "waste minimisation programme?" Understandably, the Agency has been asked this many times since the September 1985 date, after which generators were to have certified that they had such a programme in place.

The generator has a wide latitude in structuring his or her programme. Also, since Congress indicated in its accompanying report to the HSWA that "economically practicable" is to be determined by the generator and is not subject to subsequent evaluation by the EPA, the generator has even more latitude in defining a programme. The EPA has, in a Federal Register Notice dated 12th June 1989, issued some non-binding guidelines as to what the elements of an effective waste minimisation programme might include.[1]

These six elements are:

- Top management support
- Characterisation of waste generation
- Periodic waste minimisation assessments
- A cost-allocation system
- Encouragement of technology transfer
- Programme evaluation.

4.1 Top management support

The first step in developing a programme is to establish a clear corporate policy. The full commitment from management of time, personnel, and financing is extremely important. Lack of this commitment is often one of the most formidable obstacles to waste minimisation. The chances for obtaining this commitment are often enhanced by outlining the potential incentives for waste minimisation as shown in Table 2.

Economics

- Landfill disposal cost increases.
- Costly alternative treatment technologies.
- Savings in raw material and manufacturing costs.

Regulations

- Certification of a waste management programme (WMP) on the hazardous waste manifest.
- Biennial WMP reporting.
- Land disposal restrictions and bans.
- Increasing permission requirements for waste handling and treatment.

Liability

- Potential reduction in generator liability for environmental problems at both on-site and off-site treatment, storage, and disposal facilities.
- Pontential reduction in liability for worker safety.

Public image and environmental concern

- Improved image in the community and from employees.
- Concern for improving the environment.

Table 2.
Waste minimisation incentives.[12]

An appreciation of the necessity for top management support is summed up very well by G.J. Hollod: *"Lack of senior management support will doom a waste minimization program from the start. Many managers in addition to the standard business functions have become occupied with other priorities in the environmental area like land bans, right-to-know and occupational health considerations. Waste minimization is competing with other environmental priorities, but management must be convinced that waste minimization is a program that deserves priority and should be part of the 'daily diet' for the line organization and not just another environmental headache left to the site's environmental coordinator. Make waste minimization a company policy."*[10]

The objectives of a waste reduction programme are best conveyed to a business's employees through a formal policy statement or management directive. A business's upper management is responsible for establishing a formal commitment throughout all levels of the business. An environmental policy statement or the business's operating guidelines might include the following points:

- Environmental protection is a production line responsibility and an important measure of employee performance. In addition, every employee is responsible for environmental protection in the same manner as he is for safety.
- Reducing or eliminating the generation of waste has been and continues to be a prime consideration in research, process design, and plant operations, and is viewed by management like safety, yield, and loss prevention.
- Reuse and recycling of materials has been and will continue to be given first consideration prior to classification and disposal as a hazardous waste.

To quote a good example, the 3M Company of St. Paul, Minnesota, has laid down as a part of its official environmental policy that the company will "prevent pollution at the source wherever and whenever possible". It might be noted that this company has also stated that it is a part of its policy to "develop products that will have a minimum effect on the environment". While this is somewhat outside the goals of a typical waste minimisation programme,

It is clearly within the goals of an overall pollution prevention programme, and should certainly be considered by any company producing products that will ultimately end up in the waste stream.

It is also desirable to set specific goals for reducing the volume or toxicity of waste streams. Here, quantitation helps. Some examples of waste minimisation goals are described below:

The US Department of Defense is committed to reducing its hazardous waste disposal rates by 50 percent by the year 1992.

The Dupont Company has stated that its wastes will be reduced by 35 percent by 1990 as compared to 1982 values.

As a benchmark for evaluating waste minimisation goals, a report on waste reduction issued by the Congressional Office of Technology Assessment in 1986 states that: "Substantially more waste reduction is feasible and more will become feasible. Setting a national voluntary waste reduction goal of perhaps ten percent annually for five years would be useful."

Management should commit itself to implementing recommendations identified through assessments, evaluations, or other means. A sure way to undermine a programme is to not follow up on recommendations developed by a committed group of employees. Although it may be unreasonable to expect facility management to make wholesale commitments to accept recommendations, it is not unreasonable to expect it to enter into a commitment to give a high priority to considering such recommendations. Management should designate a waste minimisation coordinator and select a team at each facility to ensure effective implementation of the programme.

For a small facility with only a few waste streams, one person – such as a plant manager, plant engineer, or environmental engineer – may be responsible for the entire waste minimisation programme. For larger, highly integrated facilities with many different processes and emission sources, a team or task force might be established. The team members should represent major departments that are involved in waste generation and management and different areas of expertise. A team may include members from production, facilities/maintenance, environmental engineering, process engineering, safety and health, and quality assurance departments. The appointed minimisation "champion" should lead the effort and coordinate all involved departments. Outside consultants and/or corporate staff should also be considered, depending on the company's nature, the facility's complexity, and available in-house skills.

Employees who identify cost-effective waste minimisation opportunities should be rewarded, and employees trained in aspects of waste minimisation that relate to their job.

Employees often cause the generation of waste and they can contribute to the overall success of the waste reduction programme. Just as incentives are used to boost employee productivity, so management should also provide incentives for the development of useful waste reduction ideas. To utilise this important resource, many businesses offer employees incentives, e.g.:

- Recognition awards for outstanding waste reduction projects and individuals, as well as for resource and energy conservation projects.
- Bonuses or financial awards for innovative approaches to waste reduction.

Public recognition of such awards helps to keep the public informed of actions taken by the business to reduce and control hazardous waste. Recognition programmes can be varied to accommodate each business, the level of involvement, and local attitudes. For instance, public recognition, e.g. an award or certificate, may be welcomed by many businesses. Other businesses, however, maintain a "low profile" as a matter of policy. In such cases, a letter from the Board may be preferred. The effectiveness of the programme could be increased by combining it with other awards, e.g. an employee month programme or a percentage of the

cash savings realised by the suggestion. Regardless of the form of the incentives, employees should reap part of the benefits from their waste reduction ideas and efforts. In some businesses, meeting the waste reduction goals is used as a measure for evaluating the job performance of managers and employees.[11]

The Dow Chemical Company incorporates these elements into its widely recognised and very successful "Waste Reduction Always Pays" programme, i.e. by using company newsletters to publicise waste reduction success stories, and by giving recognition to teams of employees who propose changes that lead to decreased waste generation. This company also strives to incorporate the principles of waste reduction into all of its training activities.

4.2 Characterisation of waste generation

Maintain a waste accounting system to track the types, amounts, and hazardous constituents of wastes and the dates when they are generated. It has been our observation – and, we might add, the observation of many others active in encouraging waste minimisation – that most generators do not really know what is in their waste streams, or what possibilities might exist for reducing the volume or toxicity of the streams through relatively simple means. Information about waste streams can come from a variety of sources. Some information on waste quantities is readily available from the completed hazardous waste manifests, which include the description and quantity of hazardous waste shipped to a treatment, storage, and disposal facility. The total amount of hazardous waste shipped during a one-year period, for example, is a convenient means of measuring waste generation and waste reduction efforts. However, manifests often lack information such as chemical analysis of the waste, specific source of the waste, and the time period during which the waste was generated. Also, manifests do not cover waste water effluent, air emissions, or non-hazardous solid wastes. Potential sources of information on waste streams include[7]:

- Hazardous waste manifests
- Biennial hazardous waste generator reports
- SARA Title III Section 313, Environmental Release Reports
- Environmental audit reports
- Permits [RCRA Part B, National Pollution Discharge Elimination System (NPDES), etc.]
- Laboratory reports/characterisation data
- Chemical inventory and usage records
- NPDES monitoring reports
- Material safety data sheets (MSDSs)
- Internal waste tracking system records
- Production records.

4.3 Periodic waste minimisation assessments

One important element in a waste minimisation programme is to perform periodic waste minimisation assessments, sometimes referred to as "waste reduction audits". Conducted by an in-house assessment team or with an independent outside expert, a waste minimisation assessment is simply a structured review of potential opportunities for reducing or recycling waste. Its focus can be broad or narrow. Most find that it is usually more effective to select a few waste streams or processes for intensive assessment rather than to attempt to cover all waste streams and processes at once.

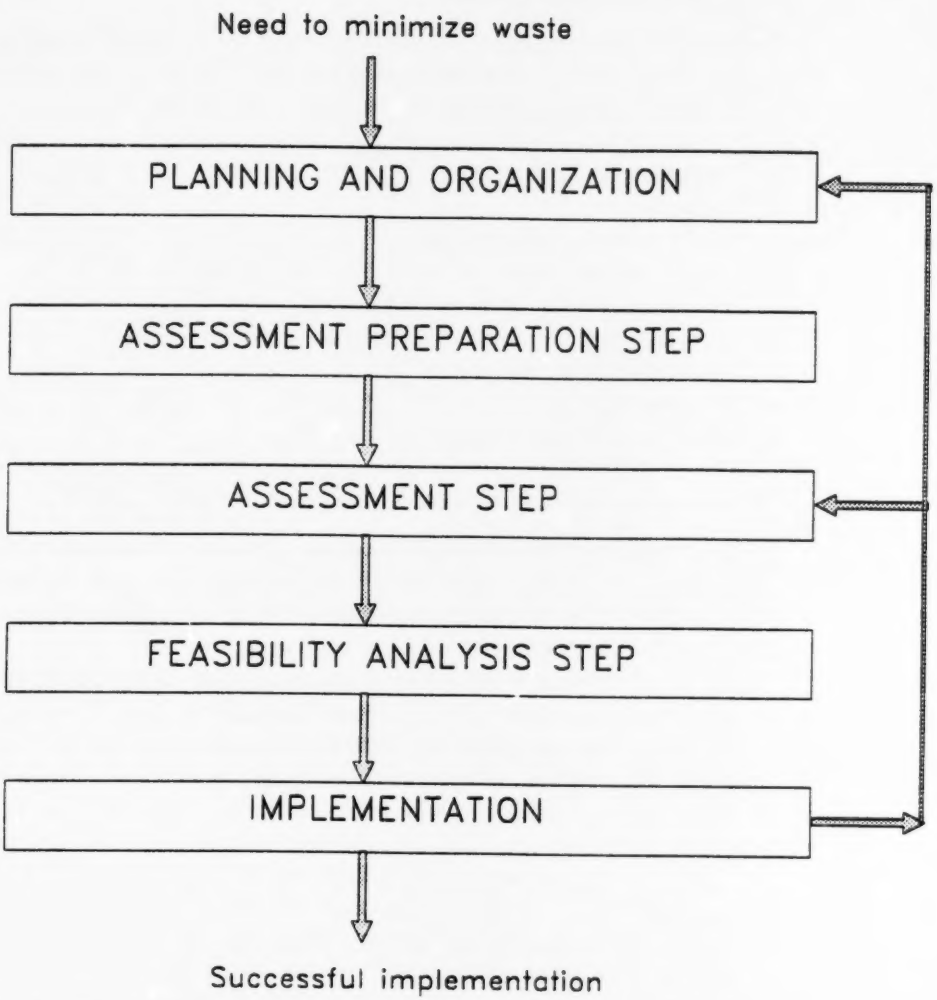

Figure 1.
Waste minimisation opportunity assessment recommended by the EPA.

The EPA has published a manual for conducting waste minimisation assessments. It is entitled "Waste Minimization Opportunity Assessment Manual". The procedure recommended by the EPA is outlined in Figure 1.[9]

Waste minimisation opportunity assessments are an extremely good way to focus attention on potential improvements.

4.4 A cost allocation system

Departments and managers should be charged "fully loaded" waste management costs for the wastes they generate. In addition to the actual disposal fee for a waste stream of interest, the generator should also consider other cost elements, such as:

- Generator fees/taxes
- Transportation
- On-site storage and handling
- Pre-disposal treatment
- Permitting, reports, and record-keeping
- Emergency preparedness and site clean-up contingency
- Pollution liability insurance
- Raw materials
- Operating and maintenance costs.

4.5 Encouragement of technology transfer

Seek or exchange technical information on waste minimisation from other parts of your company, from other firms, trade associations, State and university technical assistance programmes, or professional consultants. Many techniques have been evaluated and documented that may be useful in your facility.

To facilitate the transfer of technical information, the EPA received a mandate from Congress to establish a national clearing-house in order to provide easily accessible and reliable information on waste minimisation/pollution prevention. The clearing-house is to contain both technical information on how to identify and implement pollution prevention opportunities, as well as general information conveying the message that "we, as a society, must begin to integrate pollution prevention into the way we design, build, buy, and consume".

The EPA's Pollution Prevention Information Clearing-house (PPIC), which is supported by the Agency's Pollution Prevention Office as well as the Office of Research and Development, has been created to fulfil this mandate. PPIC (pronounced "pea pick") is being pilot-tested by some 300 – 400 users this year and will be in full operation, accessible to all, in 1990. PPIC collects and disseminates technical and other information on pollution prevention through a telephone hotline and an electronic information exchange network. Indexed bibliographies and abstracts of reports, publications, and case studies on pollution prevention will be available. PPIC will also include a calendar of pertinent conferences and seminars, information on federal and State activities and legislation, information on pollution prevention abroad, a directory of waste exchanges, and lists of knowledgeable contacts within State organisations, trade associations, and the EPA. Copies of various reports will be made available by the clearing-house either by electronic transfer or through the National Technical Information Service (NTIS) or other sources.

4.6 Programme evaluation

Conduct a periodic review of programme effectiveness. Use these reviews to provide feedback and identify potential areas for improvement.

5. Case studies

The approaches discussed below provide waste minimisation examples for generic and specific processes.[6]

Example 1: Steel producer

In 1986 the EPA sponsored a waste minimisation assessment at an electric arc furnace steel-making facility. The assessment team examined waste minimisation options, including source recovery, for the company's corrosive and heavy metal wastes. The assessment revealed that calcium fluoride (fluorspar) in the sludge generated during neutralisation of the pickling line waste water could be economically recovered. Previously, the company had disposed of the sludge and purchased 1,000 tons of fluorspar per year as flux material for the steel-making process. The waste minimisation option identified by the assessment team will save the company $100,000 per year in costs avoided to purchase fluorspar, and a further $70,000 per year because of a 30 percent reduction in the volume of sludge to be disposed of.

Example 2: Chemical plant

Changing the reactor rinse and cleaning procedures on its truckloading strainers has enabled a Californian chemical plant to reduce by 93 percent the amount of organics in its resin-manufacturing operation. Instead of allowing the phenol used in the manufacturing process to drip into the plant's sewage treatment system as a hose drains it from trucks, the company now flushes the hose with water, and the water-phenol mixture is recovered for reuse in a separate treatment system.

Example 3: Plating operation

Evaporative recovery systems can minimise the volume of waste from metal-plating baths and recycle plating solutions by recovering 90 – 95 percent of the plating solution lost through drag-out. The operating cost of the recovery system is only $.08 per gallon, while the drag-out sludge hauling and disposal costs are close to $1.00 per gallon. With only 5 – 10 percent of the drag-out requiring waste treatment, waste handling and disposal costs have been reduced significantly.

Example 4: Painting operation

The US Department of Defense has developed a new technique called Plastics Media Blasting to strip paint from military aircraft. In this process, small plastic beads are blasted at the aircraft's surface, removing the paint by abrasion. This method requires less time and generates less hazardous waste than the traditional wet paint stripping. On the basis of a test, the DOD estimates that the time required to strip an F-4 fighter has been reduced from 340 to 40 hours and that the amount of hazardous waste has been reduced from 10,000 pounds of wet sludge per aircraft to 320 pounds of dry paint chips and decomposed plastic media per aircraft.

An electric company uses a water-based electrostatic paint system instead of a conventional organic solvent paint system. This has resulted in improved quality of application, decrease in downtime from three percent to one percent, reduction in the generation of aromatic waste solvent by 95 percent, reduction in paint sludge by 97 percent, and increase in efficiency with up to 95 percent recovery and reuse of paint. The new system has reduced hazardous waste disposal costs and decreased personnel and maintenance costs by 40 percent.

6. Looking to the future

With diminishing reliance on treatment and land disposal, waste minimisation is fast becoming an essential element of immediate and long-term waste management strategy. Waste minimisation clearly provides opportunities to deal more efficiently and effectively with wastes that are hazardous to human health and the environment. Immediate financial rewards, increased waste management flexibility, and reduced dependency on landfills are a few of the benefits offered by a successful waste minimisation effort. Companies need to incorporate waste minimisation into their overall hazardous waste management programmes, just as safety is an integral part of company operations.

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